



Proton Electric to Magnetic Form Factor at Low Q^2

by Taylan Akdogan for the BLAST collaboration

Motivation for G_E^p and G_M^p

- ~ G_E^p and G_M^p are the fundamental quantities describing the electric and magnetic properties of the proton
- ~ Can be used to test first-principle calculations
- ~ Uncovers the underlying more complex system of quarks and gluons
- ~ Can be used to study pion-cloud at low Q^2

All results are preliminary

Results from thesis work of
Dr. Christopher B. Crawford
Adrian Sindile

Why BLAST for the Form Factors?

- **BLAST at Bates linear accelerator facility provides:**

- » Highly polarized, high current stored electron beam
- » Highly polarized internal gas target without any windows (low background)
- » Detection with large acceptance → wide Q^2 acceptance

- **Good systematics; ideal for spin observable:**

- » Symmetric detector design → super ratio method
- » Target polarization is flipped frequently
- » Beam polarization is reversed every ring fill (~ 15 min)
- » Stored beam polarization can be efficiently flipped for further systematic checks

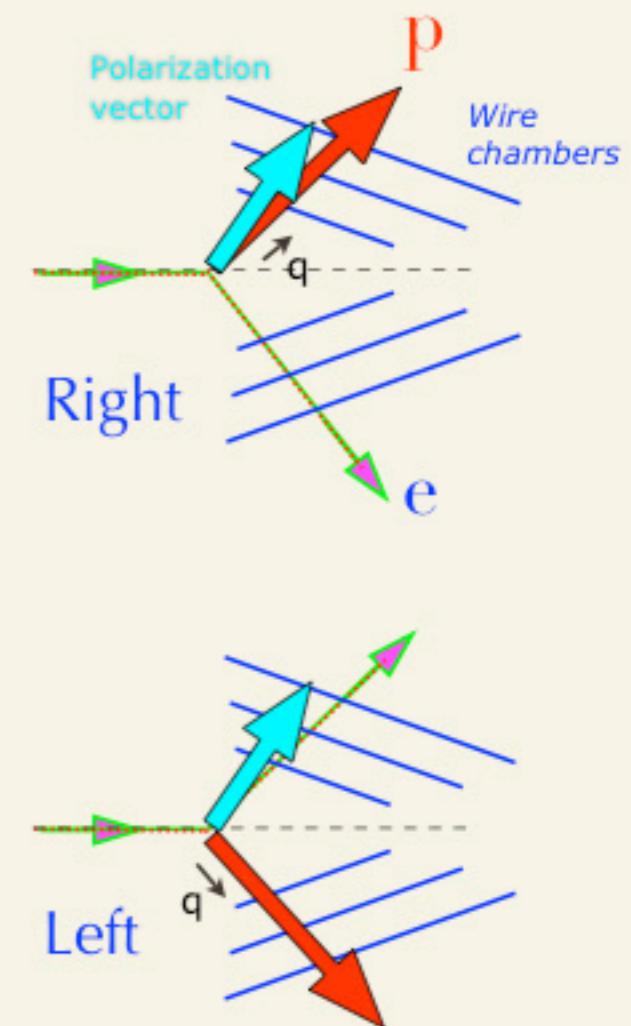
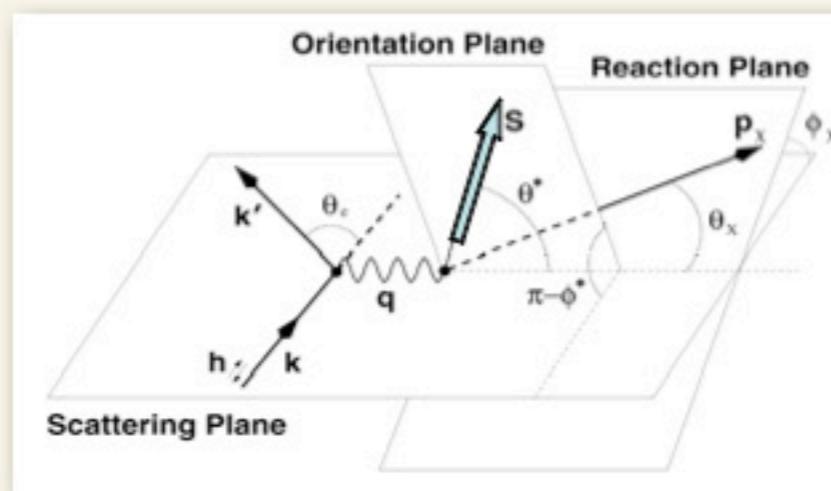
Data Analysis

- Beam-target double spin asymmetry

$$A_{\text{exp}} = P_b P_t \frac{-2\tau v_T \cos \theta^* G_M^p {}^2 + 2\sqrt{2\tau(1+\tau)} v_{TL'} \sin \theta^* \cos \phi^* G_M^p G_E^p}{(1+\tau) v_L G_E^p {}^2 + 2\tau v_T G_M^p {}^2}$$

- Super-ratio method

$$R_A = \frac{A_L}{A_R} = \frac{z_L^* - x_L^* \cdot G_E^p / G_M^p}{z_R^* - x_R^* \cdot G_E^p / G_M^p}$$



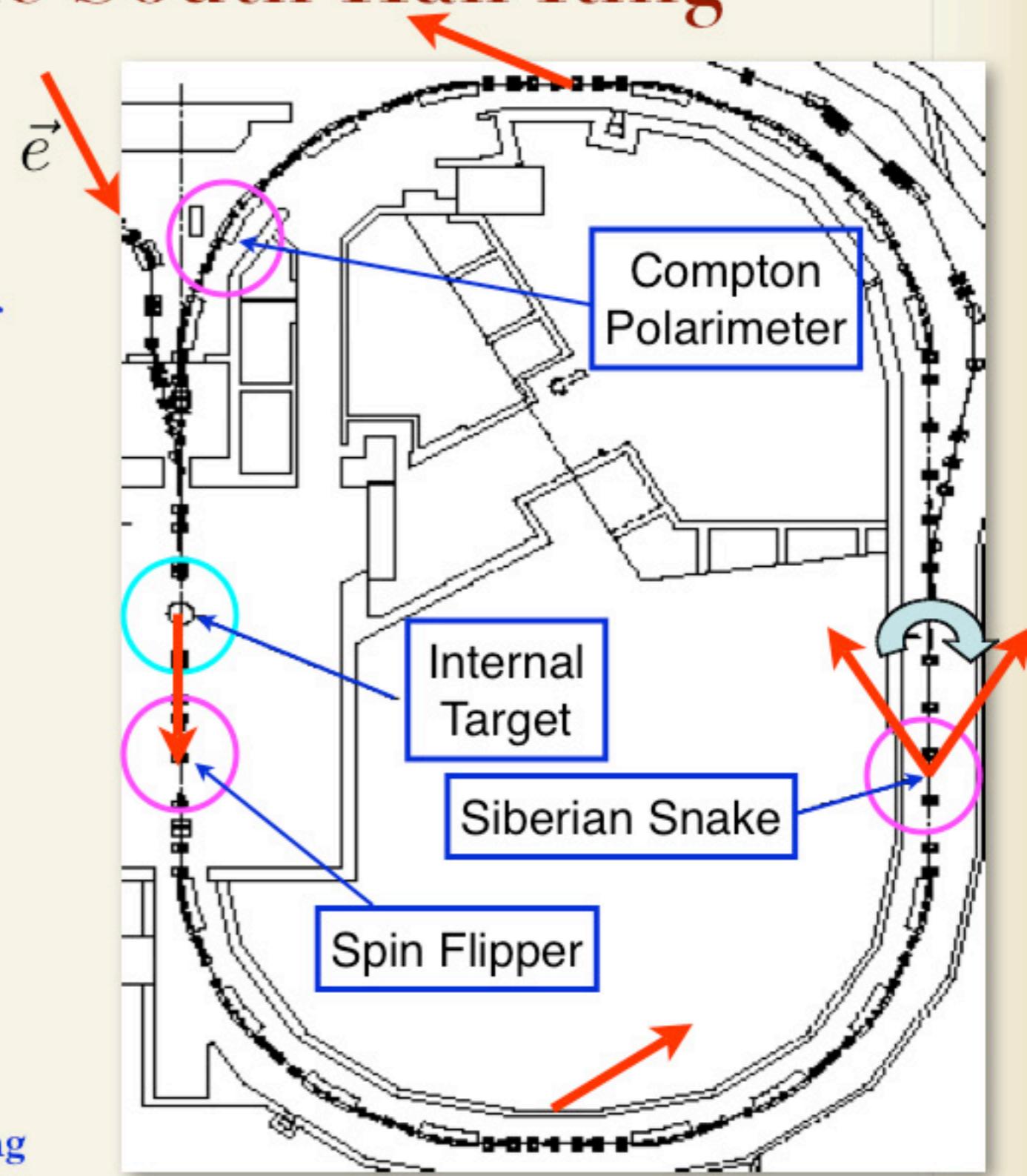
Polarization in the South Hall Ring

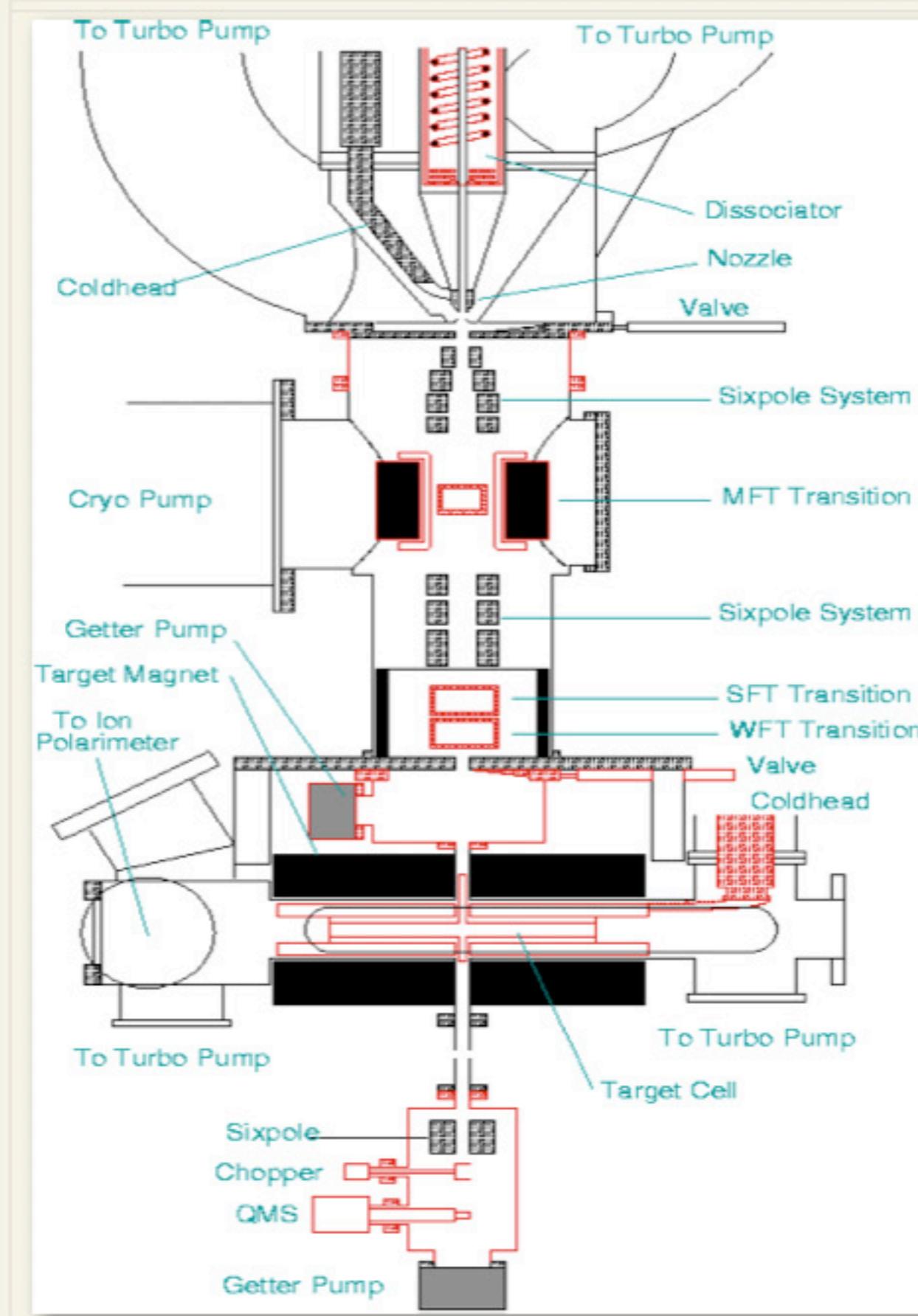
Polarized electron source

- Photoemission on HGD GaAs
- Beam polarization continuously monitored by a Compton polarimeter
- Accelerated to 850 MeV

South hall electron storage ring

- Gradual stacking up to **225 mA**; **30 min lifetime** with ABS target
- Full siberian snake for preserving longitudinal polarization
- **66% polarization** in the ring with high polarization lifetime
- Reversing beam helicity each fill for systematics
- High efficiency RF dipole spin-flipping for stored beam to study systematic errors

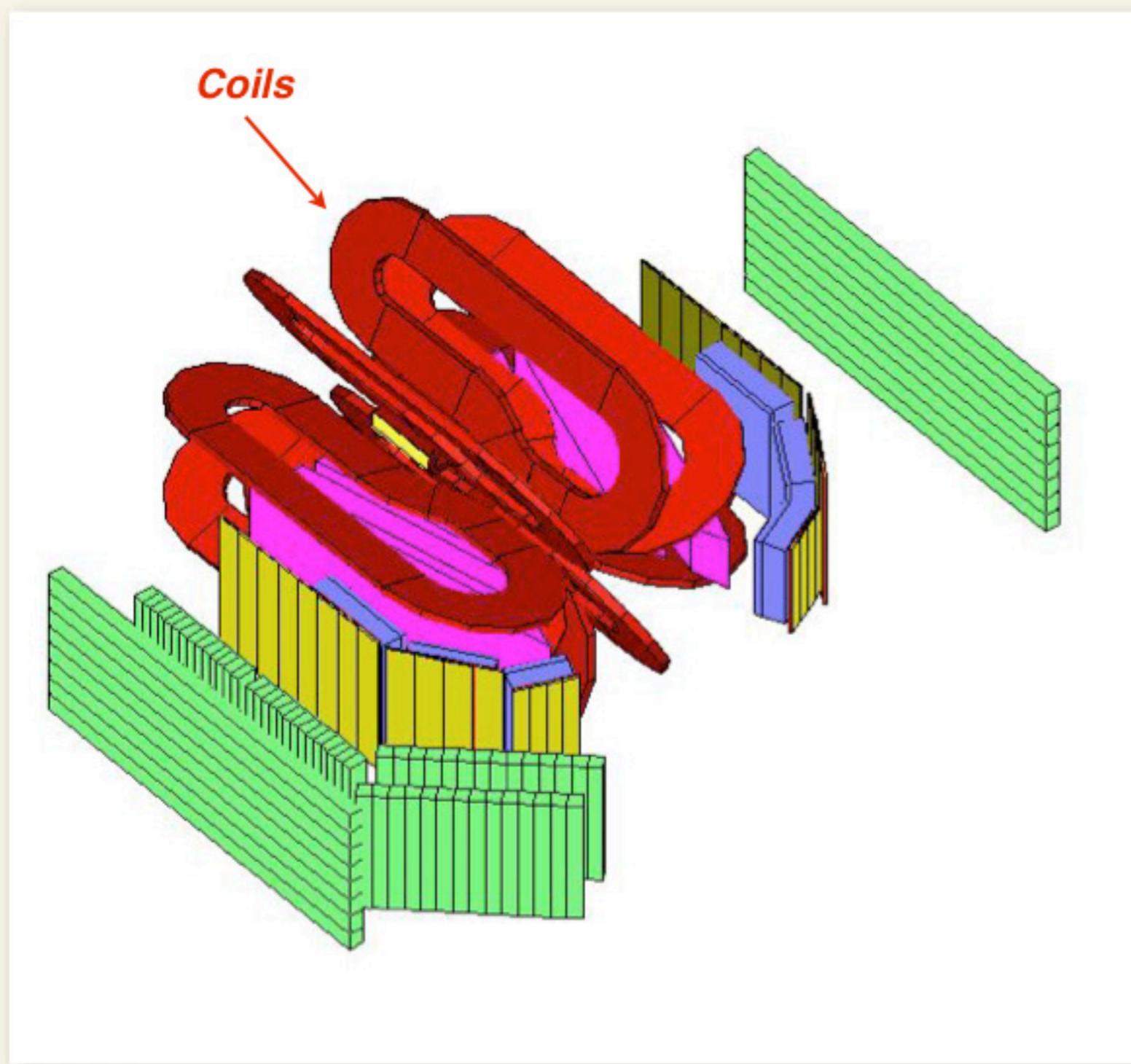




Internal Gas target

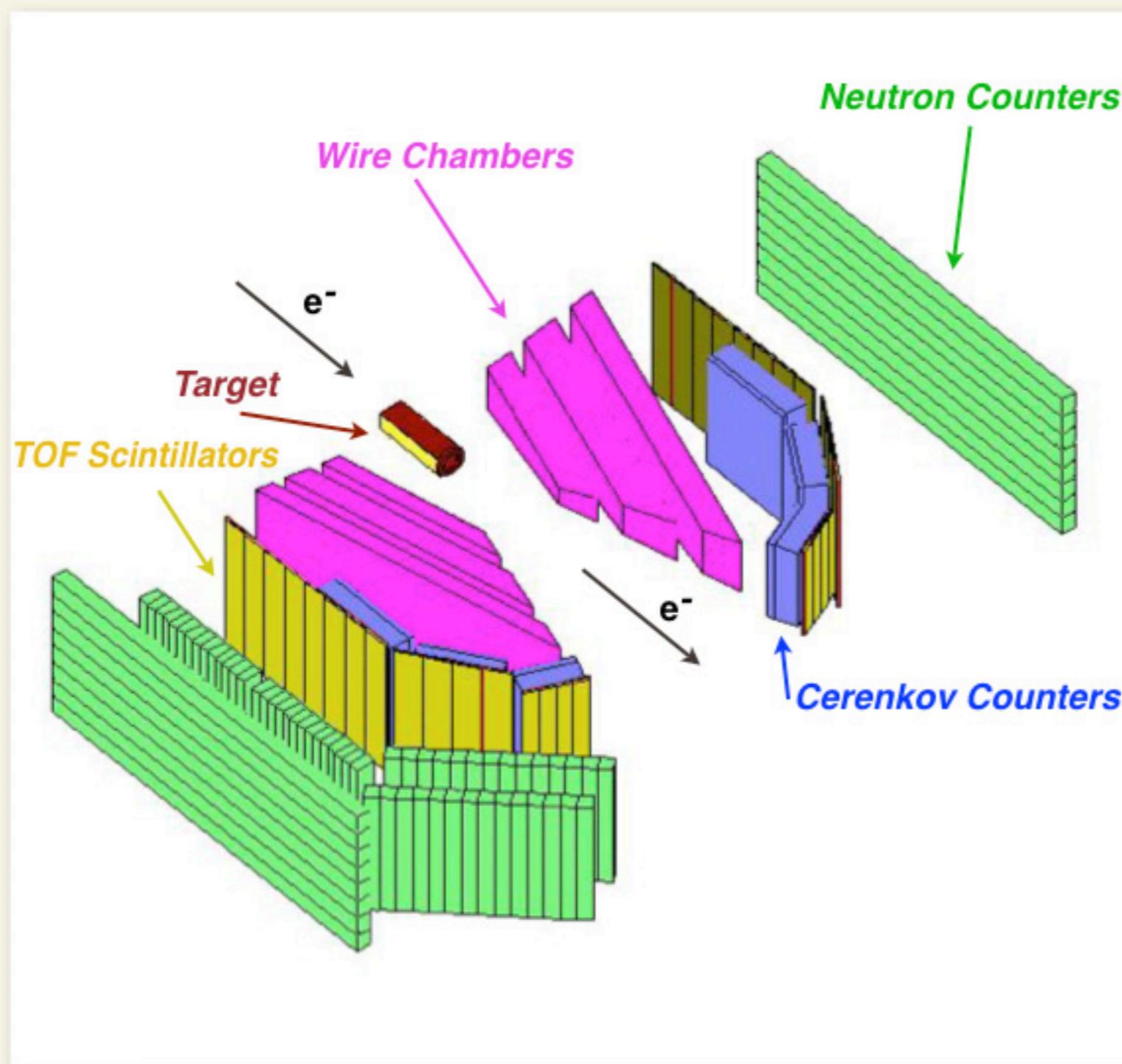
- Atomic Beam Source (ABS)
- Isotopically pure H or D
 - » vector polarized H
 - » vector and tensor polarized D
- 60 cm long open ended target cell
 - » cell diameter is 15 mm
 - » target thickness is **$5 \times 10^{13} \text{ atoms/cm}^2$**
- Holding field 32° or 47° to the left
 - » allows parallel/perpendicular kinematics simultaneously
- Mean target polarization
 - » $P_b \cdot P_t = 0.474 \rightarrow P_t = 0.72$
- Target state is flipped frequently

BLAST Detector



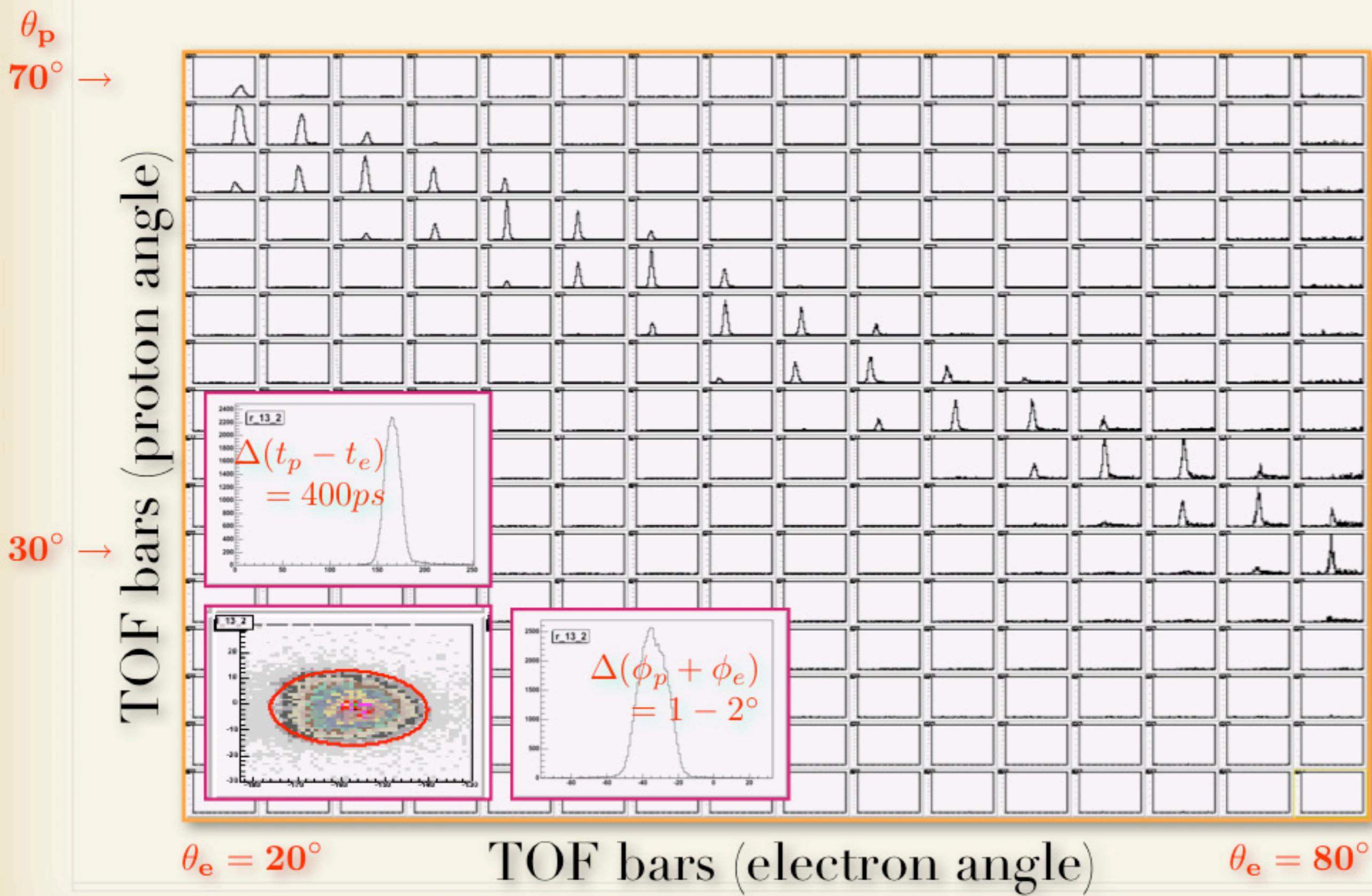
- Toroidal magnetic field
 - » 3.8 kG maximum field

BLAST Detector

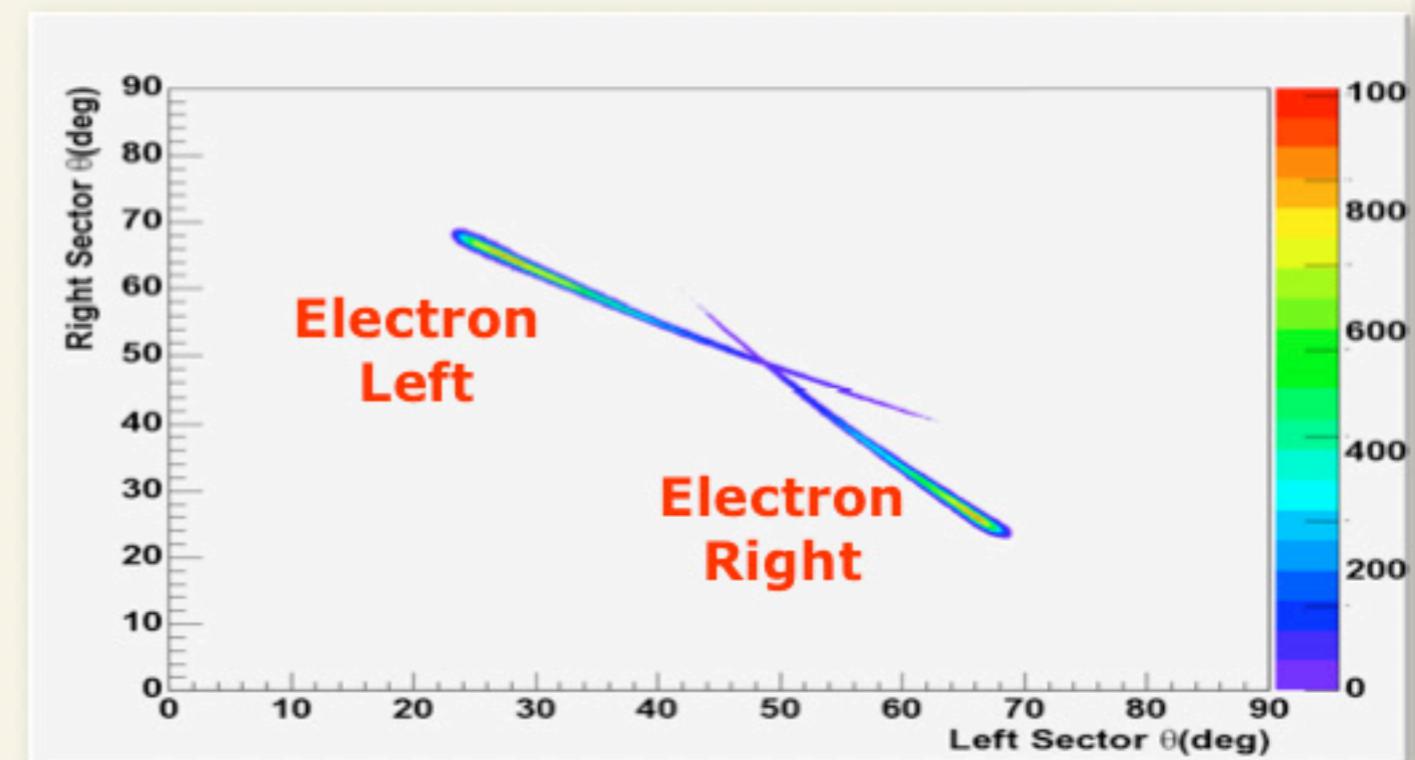
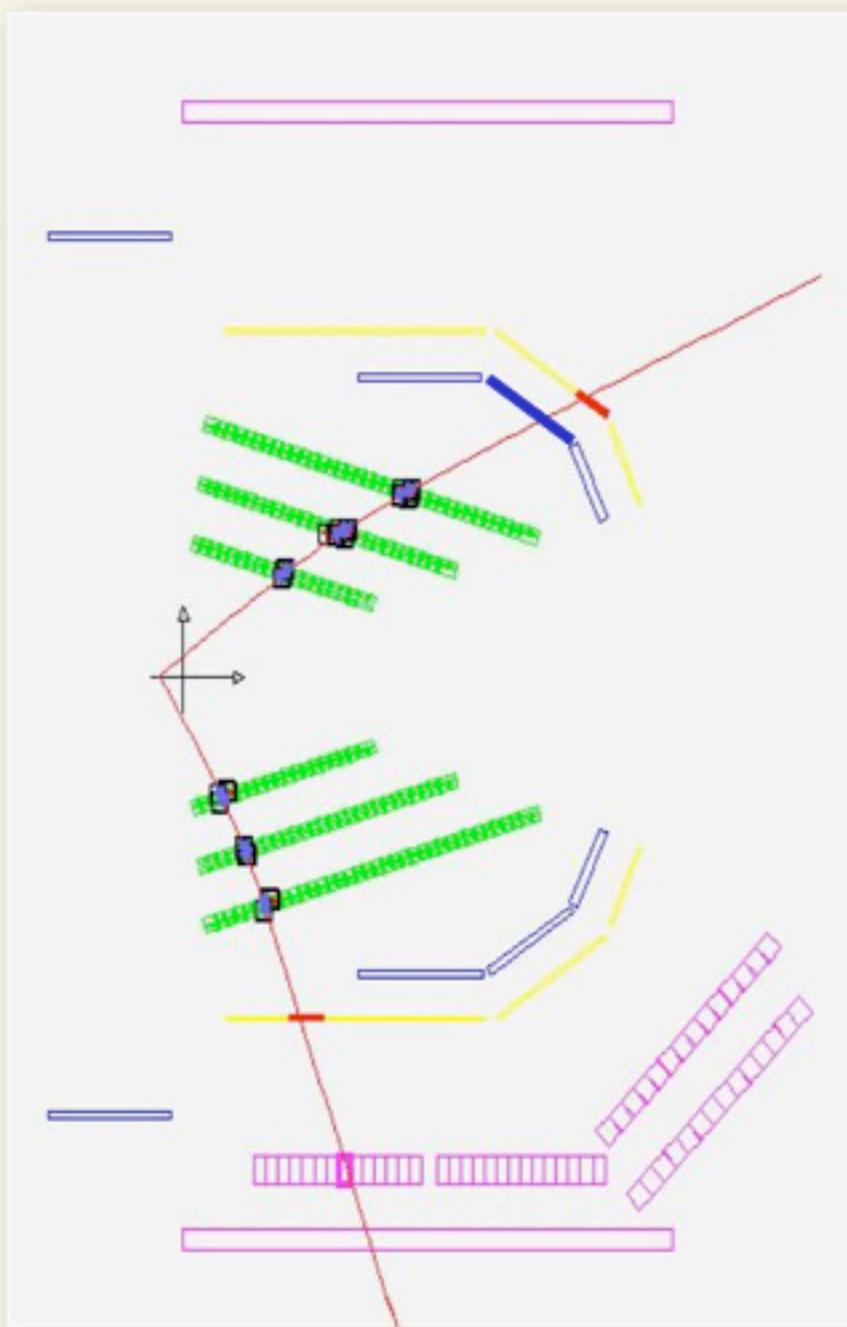


- **Toroidal magnetic field**
 - » 3.8 kG maximum field
- **Drift chambers**
 - » Charged particle tracking
 - » 18 layers at each sector
- **Cerenkov counters**
 - » ~1 cm thick aerogel
 - » electron PID
- **Time of flight scintillators**
 - » 2.5 cm thick 16 bars/sector
 - » Provides timing and trigger
- **Back Angle TOFs**
 - » Same as TOFs, at 95° - 115°
 - » Used for higher Q^2 data point
- **Neutron detectors**
 - » left sector 10 cm thick
 - » right sector 30 cm thick
 - » Used for Deuteron channels

TOF Scintillator Cuts



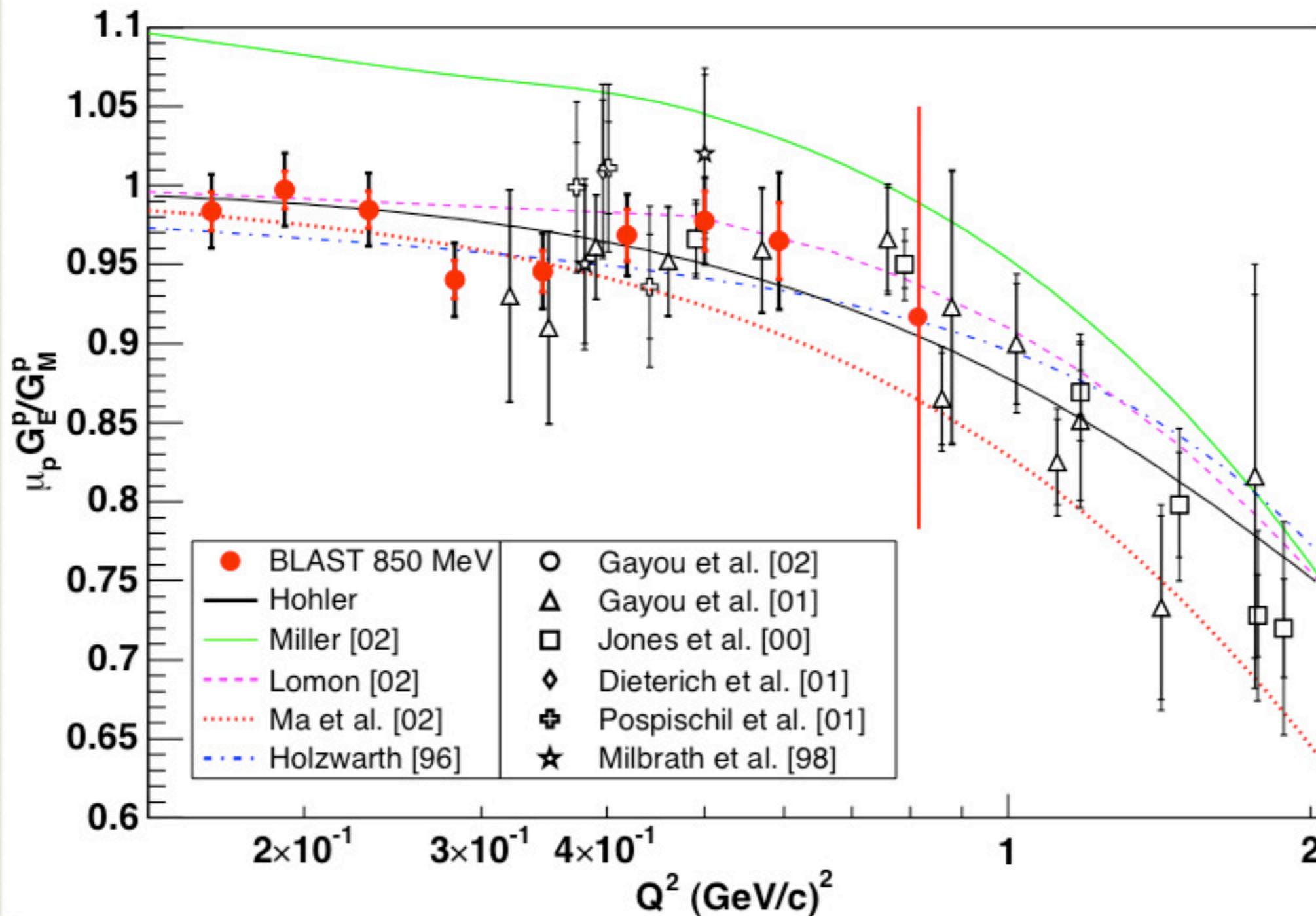
Event Construction and Resolution



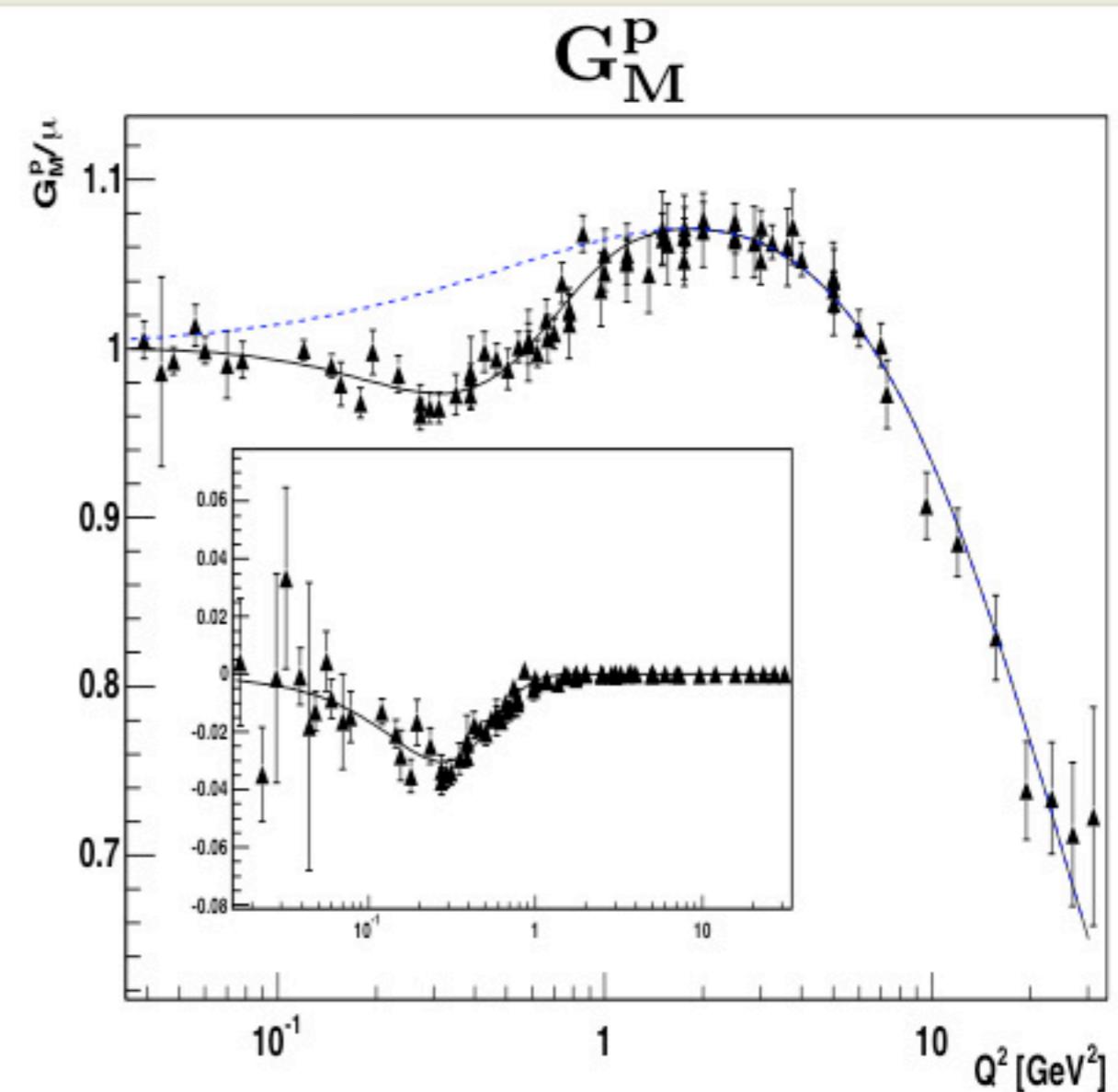
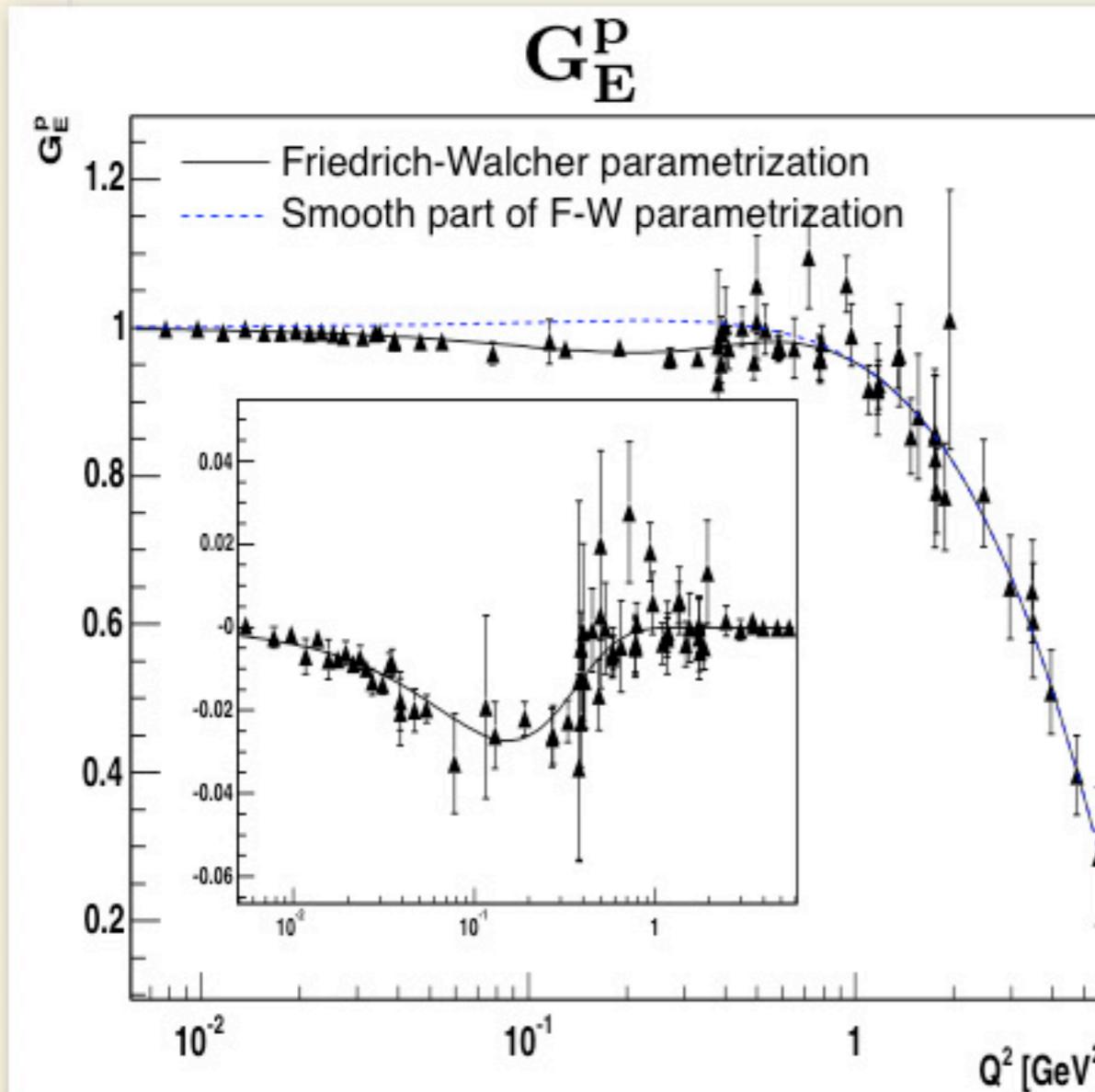
Resolution	
σ_p	< 3%
σ_θ	0.5°
σ_ϕ	0.6°
σ_z	1 cm

Ratio of G_E^P/G_M^P at BLAST

PRELIMINARY

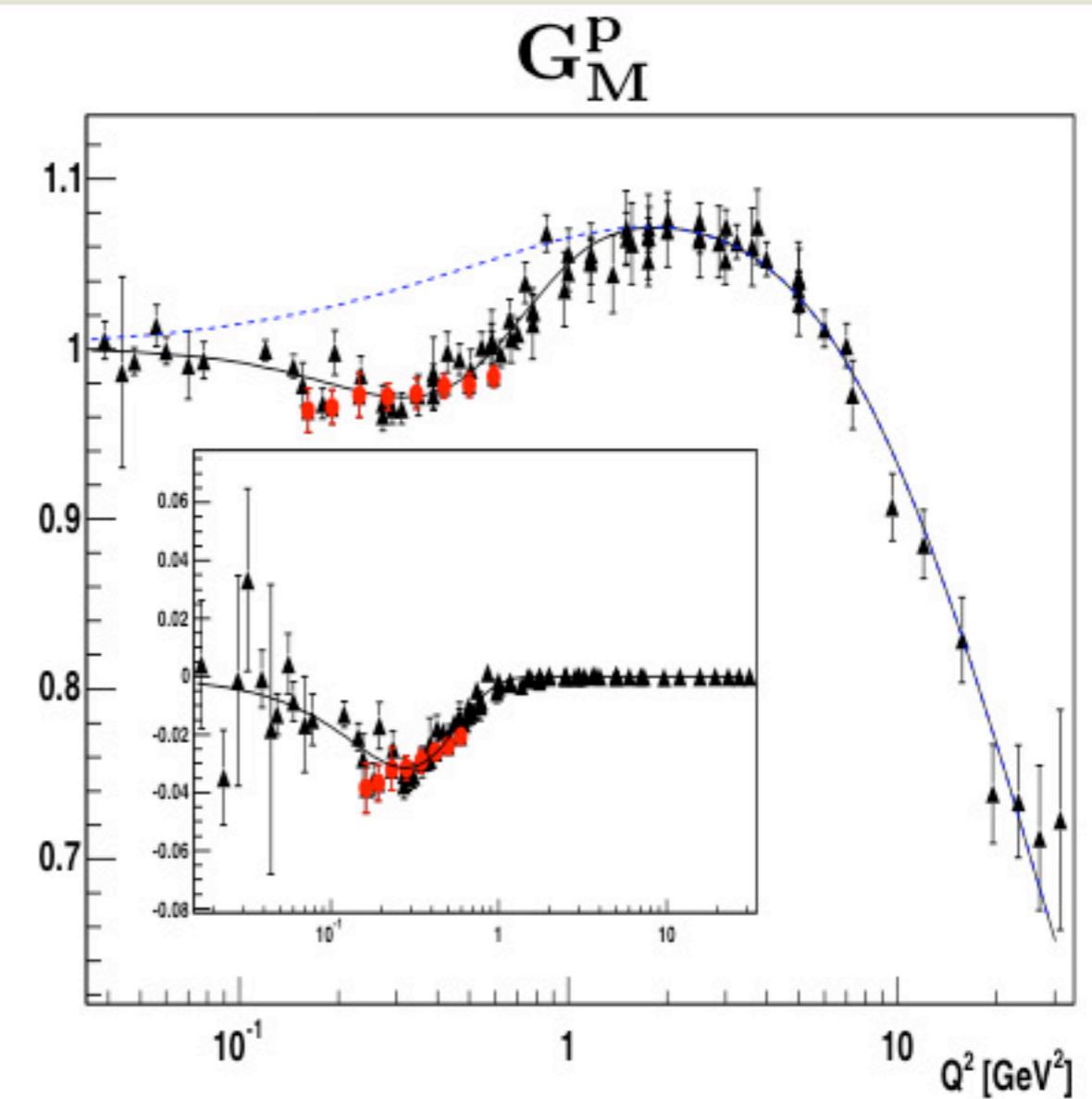
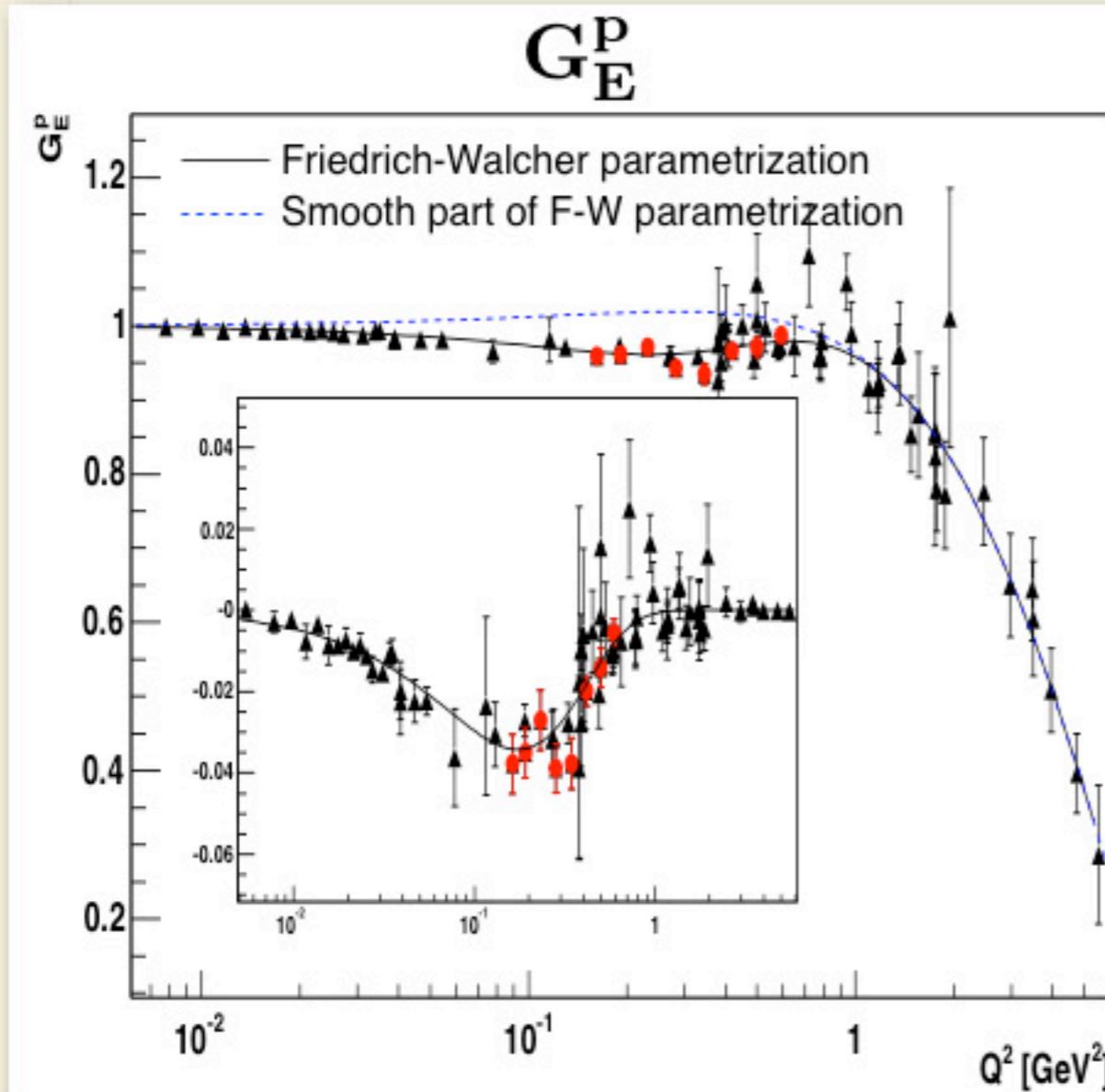


G_E^p and G_M^p World Data



G_E^p and G_M^p World Data with BLAST

PRELIMINARY



Conclusions

- Double spin-asymmetry is a powerful tool to extract $\mu G_E^p/G_M^p$
- New BLAST data doubled the precision of $\mu G_E^p/G_M^p$ measurement for the region $Q^2 = 0.3 - 0.6 \text{ GeV}^2$
- It is the first data for $Q^2 = 0.1 - 0.3 \text{ GeV}^2$ region utilizing spin-asymmetry
- G_E^p and G_M^p data are consistent with the world unpolarized data which show a pronounced dip for pion-cloud
- G_E^p data shows a narrow dip at around $Q^2 = 0.3 \text{ GeV}^2$
(under investigation)

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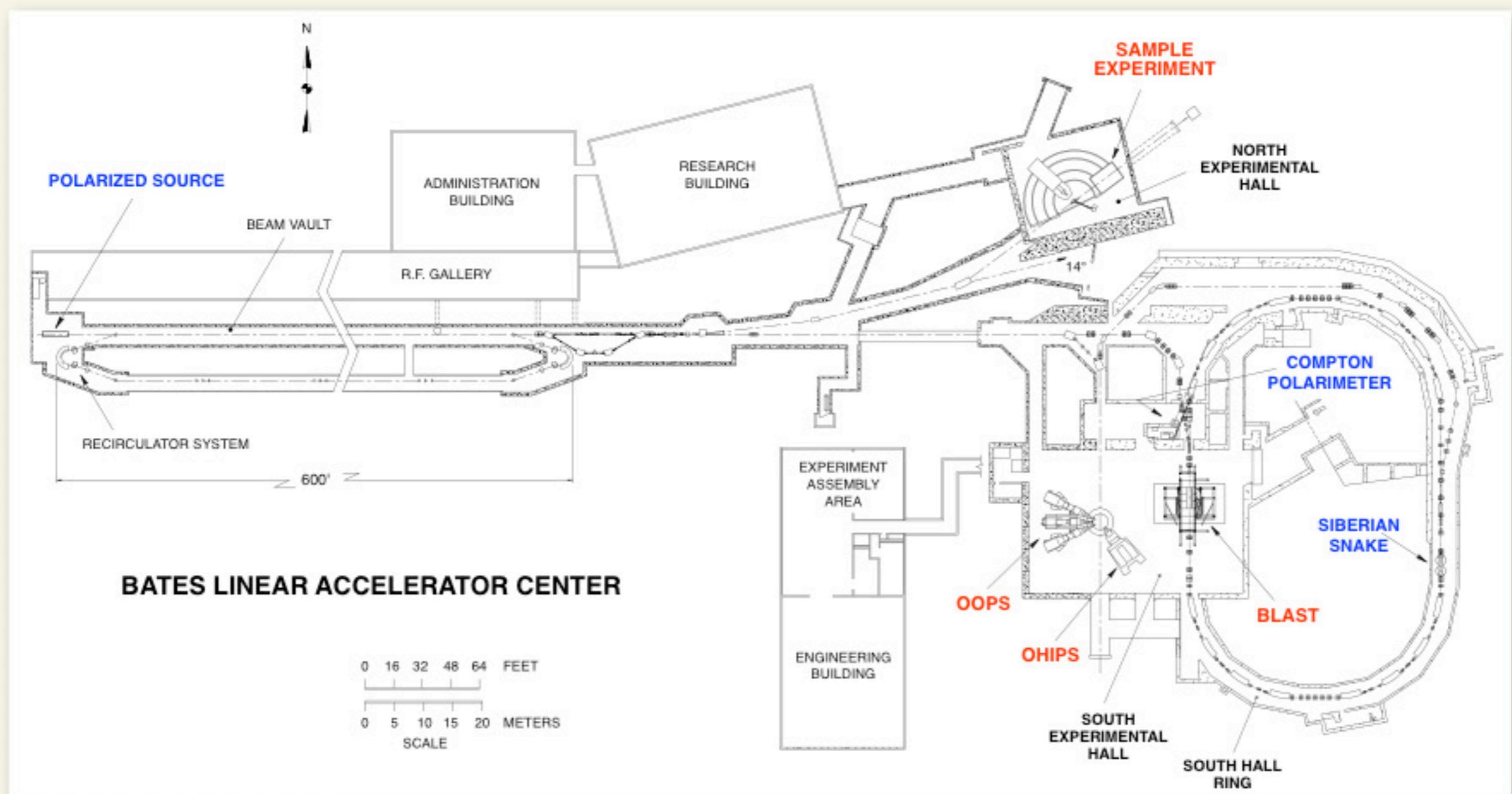
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Bates Linear Accelerator Center



Three distinct modes of operation driven by needs of experiments

- ~ Standard: Linac and recirculator provide intense polarized electron beams up to 1GeV at 600 Hz, low duty cycle
- ~ Pulse Stretcher (OOPS): Limited turns in South Hall Ring before gradual extraction to external target
- ~ Storage (BLAST): Gradual stacking of electron pulses in South Hall Ring for long-lived CW beam

PRELIMINARY

GE and GM - World Data

